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Optimization of DE Jong's Function Using Genetic Algorithm Approach

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***Abstract*— Genetic algorithm is a search algorithm based on the mechanics of natural selection and natural genetics. The purpose of this master thesis is to optimize/maximize de Jong's function1 in GA using different selection schemes (like roulette wheel,random selection, besy fit/elitist fit rank selection, tournament selection). For our problem the fitness function chosen is from literature of benchmark functions commonly used in order to test optimization procedures dedicated for multidimensional, continuous optimization task. The terminating Criterion is the number of iterations for which the algorithm runs**

***Index Terms*— De Jong's function, roulette wheel selection, elitist fit rank selection**

I. Introduction

The genetic algorithm is a search algorithm based on the mechanics of natural selection and natural genetics. As summarized by Tomassini , the main idea is that in order for a population of individuals to adapt to some environment, it should behave like a natural system. This means that survival and reproduction of an individual is promoted by the elimination of useless or harmful traits and by rewarding useful behavior. The genetic algorithm belongs to the family of evolutionary algorithms, along with genetic programming, evolution strategies, and evolutionary programming. Evolutionary algorithms can be considered as a broad class of stochastic optimization techniques.

An evolutionary algorithm maintains a population of candidate solutions for the problem at hand. The population is then evolved by the iterative application of a set of stochastic operators. The set of operators usually consists of mutation, recombination, and selection or something very similar. Globally satisfactory, if sub-optimal, solutions to the problem are found in much the same way as populations in nature adapt to their surrounding environment.

Using Tomassini's terms, genetic algorithms (GA's) consider an optimization problem as the environment where feasible solutions are the individuals living in that environment. The degree of adaptation of an individual to its environment is the counterpart of the fitness function evaluated on a solution. Similarly, a set of feasible solutions takes the place of a population of organisms. An individual is a string of binary digits or some other set of symbols drawn from a finite set. Each encoded individual in the population may be viewed as a representation of a particular solution to a problem.

De Jon'g function is popular in genetic algorithm literature. Is is also known as sphere model. It is continuous, convex and unimodal.

Function definition:

$$F_1(x) = \sum_{i=1}^{n} x_i^2 \quad , -5.12<=x_i<=5.12$$

F_1(x)=sum(x(i)^2), where, i =1:n and -5.12<=x(i)<=5.12.

Global minimum is at: f (x)=0, x(i)=0, where, i =1:n.

II. DIFFERENCE BETWEEN GENETIC ALGORITHM AND OTHER COVENTIONAL TECHNIQUES

- GA's operate with coded versions of the problem parameters rather than parameters themselves i.e., GA works with the coding of solution set and not with the solution itself.
- Almost all conventional optimization techniques search from a single point but GA's always operate on a whole population of points (strings) i.e., GA uses population of solutions rather than a single solution for searching. This plays a major role to the robustness of genetic algorithms. It improves the chance of reaching the global optimum and also helps in avoiding local stationary point.
- GA uses fitness function for evaluation rather than derivatives. As a result, they can be applied to any kind of continuous or discrete optimization problems. The key point to give stress here is to identify and specify a meaningful decoding function.
- GA's use probabilistic transition rules while conventional methods for continuous optimization apply deterministic transition rules i.e., GA's does not use deterministic rules.

III. PROBLEM FORMULATION

For our problem the fitness function chosen is from literature of benchmark functions commonly used in order

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to test optimization procedures dedicated for multidimensional, continuous optimization task. The quality of optimization procedures are frequently evaluated by using common standard literature benchmarks.

There are several classes of such test functions, all of them are continuous:

(a) Unimodal, convex, multidimensional,

(b) Multimodal, two-dimensional with a small number of local extremes,

(c) Multimodal, two-dimensional with huge number of local extremes

(d) Multimodal, multidimensional, with huge number of local extremes.

The one which is used in this work is De Jong's function 1, also called as sphere model. The simplest test function is De Jong's function 1. It is also known as sphere model. It is continuous, convex and unimodal. It has the following general definition:

$$F_1(x) = \sum_{i=1}^{n} x_i^2 \quad , -5.12 <= x_i <= 5.12$$

F_1(x)=sum(x(i)^2), where, i =1:n and -5.12<=x(i)<=5.12.

Global minimum is at: f (x)=0, x(i)=0, where, i =1:n.

IV. WHY THIS PROBLEM IS CHOOSEN

Genetic Algorithm has an interest of me. Due to this interest I have chosen this genetic algorithm approach to optimize De jong's function1. There are several bench mark functions named de jong's function1, axis parallel hyper-ellipsoid function, rotated hyper-ellipsoid function, moved axis parallel hyper-ellipsoid function, rosenbrock's valley(de jong's function2), rastrigin's function6, schwefel's function7, grienwangk's function8, sum of different power function9, ackley's path function10, langermann's function11, michalewicz's function12, branins rcos function, easom's function, goldstein-price's function and six-hump camel back function. I have selected de jong's function1. I have selected this function because of its simplicity. Three selection algorithm has been used with this function to optimize this function i.e roulette wheel, random selection, best fit/elitist fit. I have compared this three selection algortihm to show which algorithm gives best result.

V. ANALYZING SELECTION METHOD PERFORMANCE

Some chromosomes are randomly chosen and calculated the fitness value using some selection algorithms. It has been shown with the help of table given below that different algorithm gives different value by applying different number of iterations.

No. of Iterations	Fitness Values		
	Roulette Wheel Selection	Random Selection	Best Fit/Elitist Selection
10	64.58	60.15	58.64
20	73.61	67.27	60.82
30	75.64	71.56	63.12
40	80.76	70.24	69.71
50	86.78	64.18	70.17
60	88.73	60.74	74.74
70	93.27	68.42	78.36
80	107.38	73.78	84.70
90	116.28	89.92	98.88

Comparison of fitness values with different selection techniques

Here it is shown that, how in different number of iterations the fitness values of different selection techniques changes and one of them finally reaches a maximum value, optimizing the function under processing.

As it can be seen here the random selection converges to a value which is very less as compared to the other selection techniques under consideration, whereas the other technique i.e. Best Fit/Elitist usually gives better results as compared to the other one, but is far less as compared to the roulette wheel selection. So it is clear that out of the three better one is roulette wheel selection.

VI. CONCLUSION

The word Function optimization/maximization is the main point of discussion in this dissertation. Actually this dissertation is based on implementing De Jong's function1 i.e. sphere model using different selection techniques used in Genetic algorithm and making a comparison of them based on the fitness values of function at different number of iterations.

Basically GA is one of the better function optimization methods generally employed now days. De Jong's function1, also known as sphere model is one of the various benchmark functions that can be found in the GA's literature.

The encoding scheme for this problem of function maximization is value/real encoding. And so a different type of crossover method is applied for crossing the chromosomes in the population for producing better offspring's. And finally the mutation method used is also different than the usual ones. Uniform mutation is used while implementing this algorithm.

The main point around which all this work revolves is the different selection techniques employed for running this algorithm. All other parameters are kept constant, except the three selection techniques (Roulette wheel, Random selection and Best Fit/Elitist). Termination criteria chosen is the number of iterations and the function reaching its maximum value.

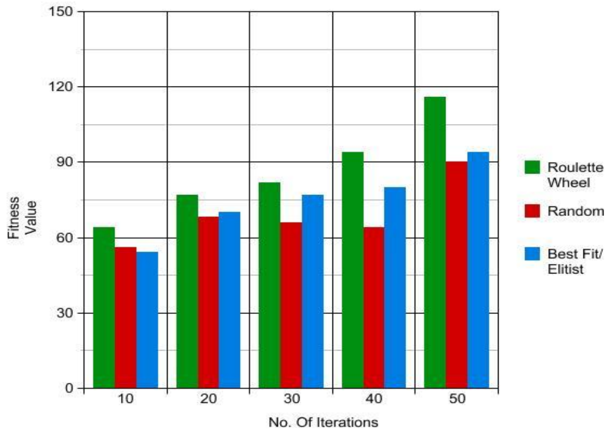
After all the experimentation and implementation, results that came out are like, out of all these three selection techniques, best one is the roulette wheel selection. Roulette wheel is a probability based selection technique.

VII. FUTURE SCOPE

In future, further other different selection techniques can be employed for maximizing this function. And other prospect in future can be, changing other parts of the genetic algorithm keeping a particular selection technique fixed which might finally show even better results as compared to that came now. And further a larger size of chromosomes could be used for better results.

VIII. RESULTS

The procedure followed while implementing it is first started with randomly generating the population of chromosomes, for this implementation population chosen is 4 only with each chromosome having length of 5 genes. This process in GA has been called as encoding the input population.



Results of various selection techniques for appt. no. of iterations.

Then one of the selection techniques has been employed over the encoded population and after that a special type of crossover is performed, i.e. arithmetic crossover. After the crossover operation, mutation is performed, but after every 5 iterations. Then this operation is repeated for the required number of iterations. The results generated for our problem at hand are shown in Figure below

The bar graph shown here is about the results showing the fitness values of various selection techniques, when applied for de Jong's function1. The results that came out are in favour of the roulette wheel selection technique. With this technique for implementing de Jong's function1 results in convergence towards the maximum attainable value within the specified number of iterations. But with other functions the function converges to a less optimal value. So, with these results it can be interpreted that when de Jong's function1 is being implemented with these three selection techniques (keeping other parameters of a genetic algorithm as constant), the roulette wheel selection gives better results. Further these results can be shown using line graphs also, comparing the results for these three selection methods.

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